AOIT Computer Networking

Lesson 2

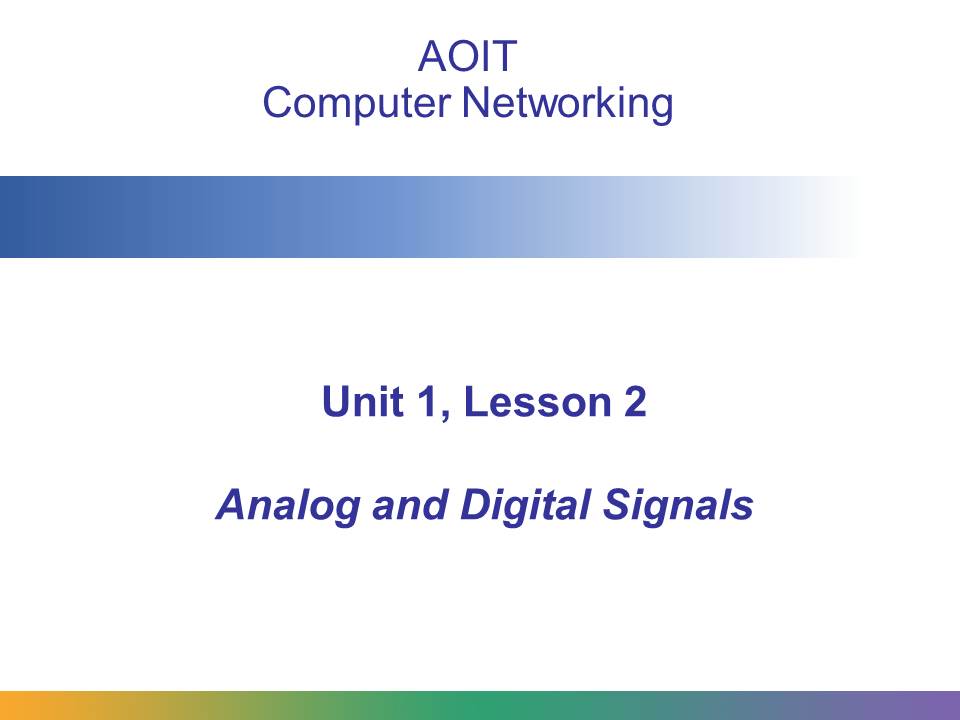
Introduction to Networking

Student Resources

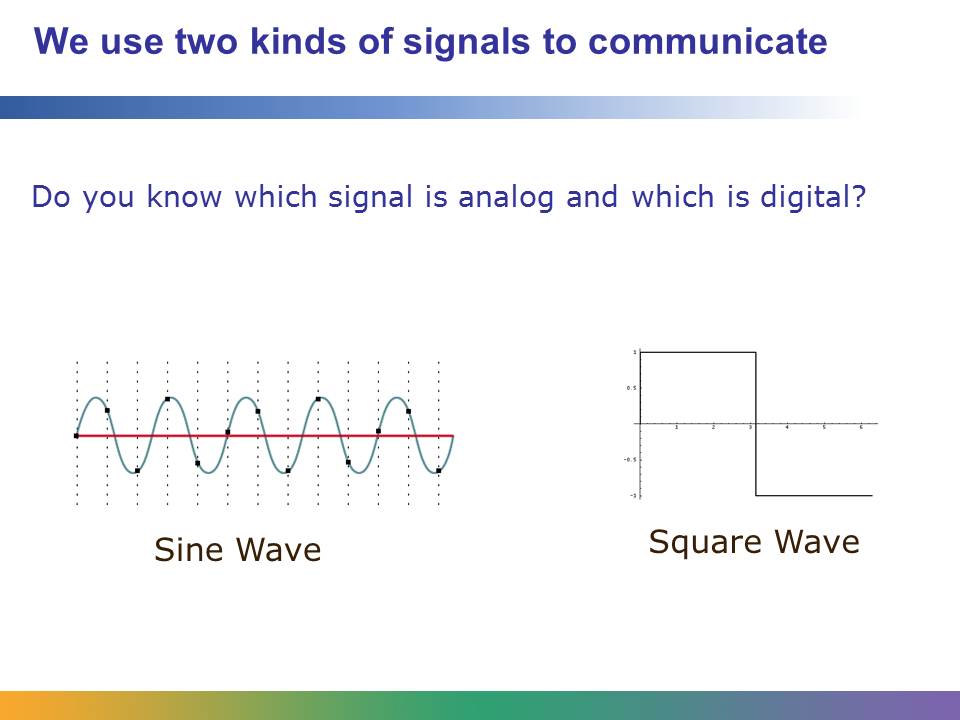
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Student Resource 2.1

Reading: Analog and Digital Signals

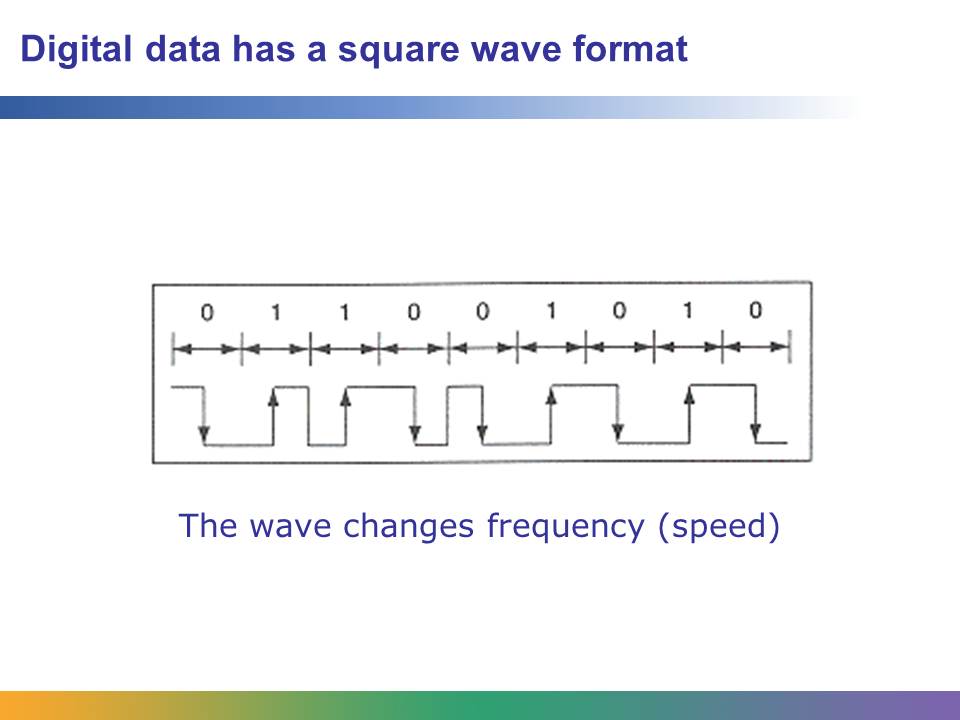


This presentation describes the physical qualities of analog and digital signals and how those signals are used in communications networks.



Do you know which is the analog and which is the digital signal?

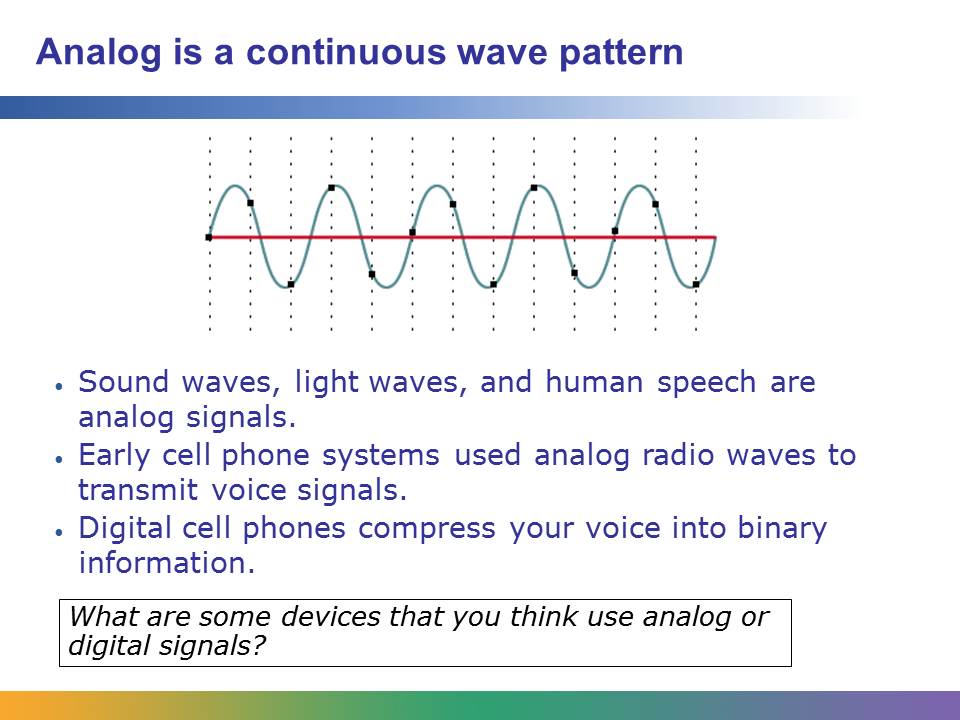
Here’s a clue to help you think about the differences between the two types of signals: an analog signal is continuous; a digital signal is either on or off.



This graph shows the square waveforms used by digital networks. The ups and downs in the waveform show changes in frequency. Can you see how the spacing between the high and low spots is different as the wave travels from left to right? This shows how the frequency changes over time and how this might be interpreted into binary—one and zero, on or off.

Computer systems use binary code to communicate. Ones and zeros are strung together to form instructions to the computer. Computer networks use electric pulses across wire to communicate. The pulses travel with less static and interference than analog signals, which tend to degrade more across longer distances.

In and of itself, a digital signal means nothing, but we can assign different meanings to it. We just need to make sure that the computers reading the signal know how to properly interpret it.



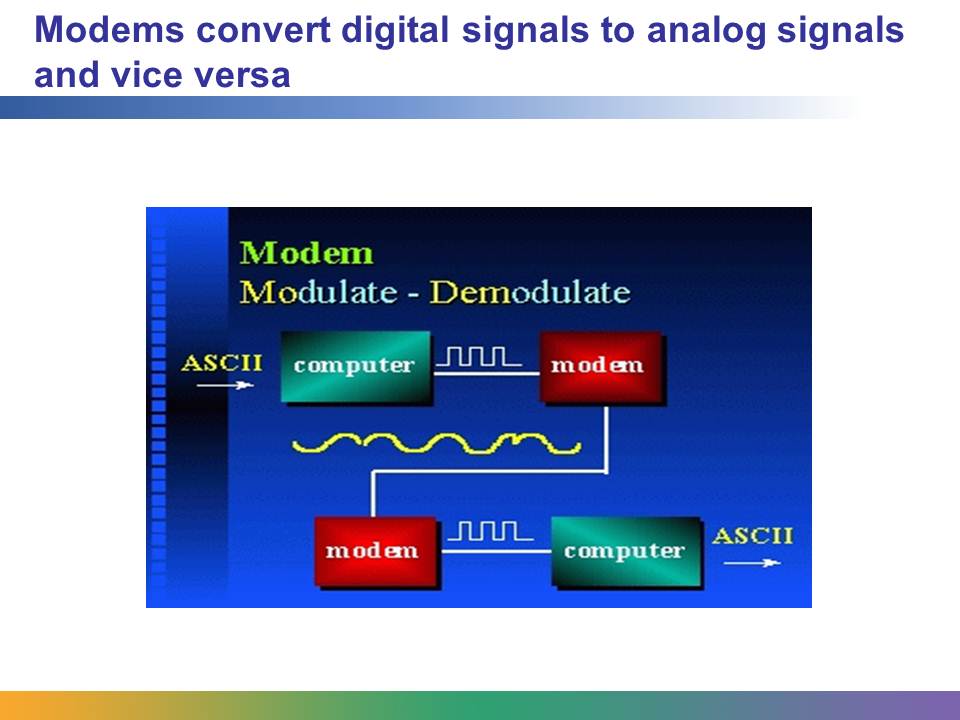
The sound of the human voice is an example of an analog signal. So, what makes it different from a digital signal?

An analog signal is a wave pattern that is continuously variable.

In the world around us, all sounds are actually analog sounds. Everything we perceive has a gradual change over time. Examples of analog signals include sound and light waves. Audio tape cassettes are analog; CDs and DVDs are digital.

Early cell phone systems used analog radio waves to transmit voice signals, so they were analog.

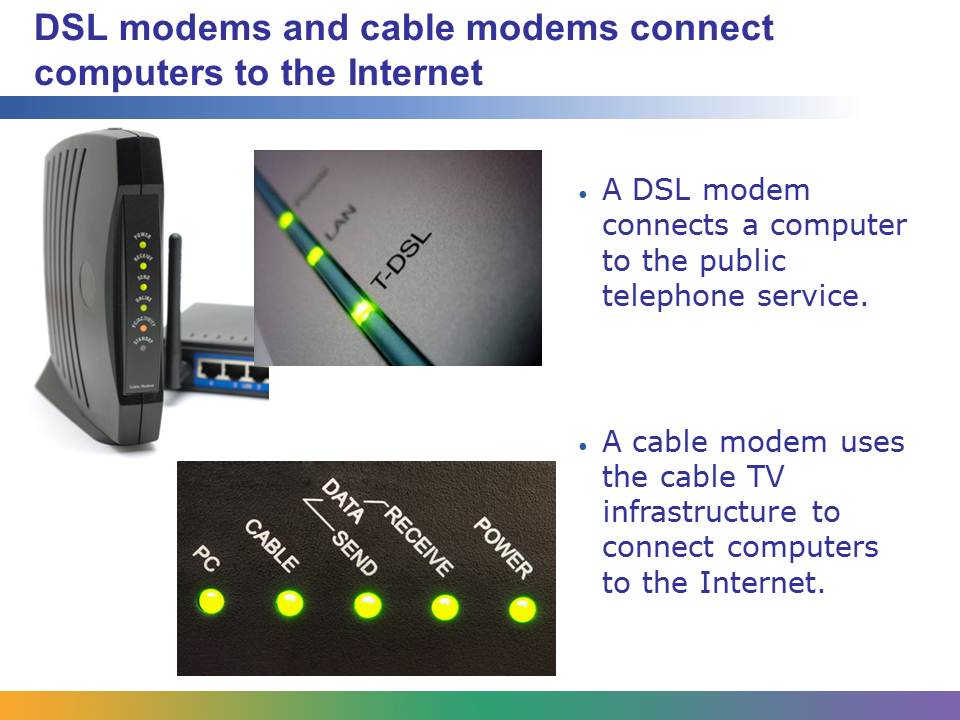
Second-generation (2G) and later cell phones are digital. They use the same radio technology as the early analog cell phones, but the digital signal is compressed in a way that analog signals cannot be. Digital cell phones compress your voice into binary information. Because they can be compressed, digital signals allow more channels to fit in a given bandwidth.



Modems are used to connect computers to the Internet via analog phone lines. The word *modem* is short for MOdulate and DEModulate, because this is what a modem must do in order to connect the digital to an analog signal.

When a user connects to the Internet on a telephone wire, the binary code is modulated and transformed to an analog one via a modem; it is then demodulated—or translated back to binary—at the other end.

ASCII is the system we use to translate the alphabets we type on a computer into the computer’s native binary language. Our full, rich alphabets of 26 letters, 10 numbers, and all the other symbols we use (such as punctuation) are too complicated for the computer, since it uses only electric pulses to communicate. So, ASCII translates the symbols into something the computer can understand within its binary structure.



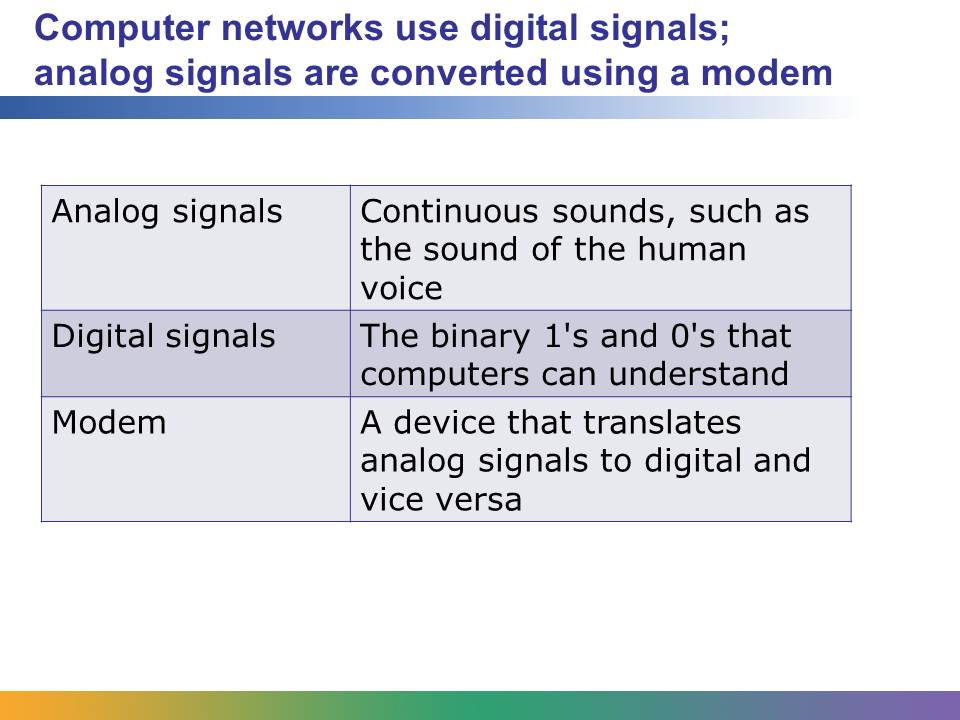
The first computer networks relied on analog telephone lines to connect. Since the computer spoke in binary but the phone lines used only analog signals, the computer was connected to a modem, which translated the message into an analog signal. On the other end, the analog signal coming from the telephone line was converted back to a digital one so that the other computer could read it.

Today, most people use cable or DSL—digital lines—to connect to the Internet, which is a purely digital network.

DSL service uses a DSL modem to connect your computer to your public telephone service.

Cable service uses the cable TV infrastructure to bring an Internet connection to your home, school, or office. Cable companies that provide Internet service require you to use a cable modem to connect your computer to the Internet.

Some Internet service providers offer voice over Internet Protocol (VoIP) technology, which uses a modem that separates voice information from data. With VoIP, you don’t need a land line. Some telephone companies do not offer DSL service without telephone line service, although more companies are beginning to unbundle their DSL and phone services. Currently, VoIP is more popular with cable modem users.



As you learn more about computer networks, you will build on everything that you have learned about analog and digital signals.

Student Resource 2.2

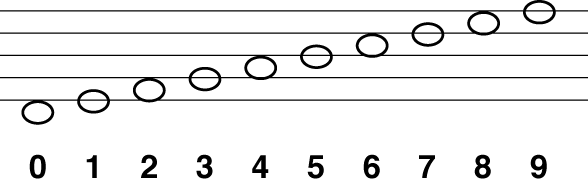
Worksheet: Creating Analog Signals

Student Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date:\_\_\_\_\_\_\_\_\_\_\_

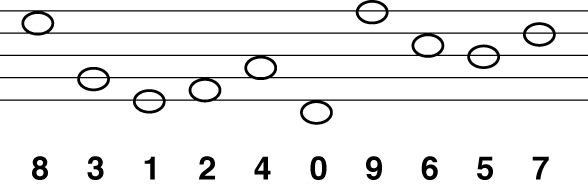
Directions: Create your own analog signal using the following analog code. Each number is represented by a symbol that is similar to a musical scale. On the blank scales below, translate your phone number (the outgoing number) and the phone number of someone you call often, such as a friend (the incoming number). An example is provided. Then swap papers with your partner and write the translated number below the notes, as in the example.

Analog signals can use different pitches, or tones, to communicate messages. For example, when you make a phone call, you can hear that each number has its own musical tone, or a different pitch from the other numbers. These tones tell the phone company what number you are trying to dial. When you dial a call, you do so by number—but the phone doesn’t understand the numbers, just the tones. So, it’s really listening to the tonal signal it receives and it uses that signal to make the call.

Musical Code



Example Phone Number



Outgoing number:

Incoming number:

Student Resource 2.3

Worksheet: Creating Digital Signals

Student Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date:\_\_\_\_\_\_\_\_\_\_\_

Directions: Morse code is a digital alphabet that was created for transmitting electrical signals over the telegraph. The amount of electricity, or volts, going over the wire is always the same, but the length of time the electricity lasts can change. Operators use an alphabet of dots and dashes, also known as dits and dahs, to write messages. Dots are short sounds, and dashes are long sounds.

Using Morse code, create your own digital signal for your partner to interpret. In the space provided, translate the full name of someone you know into Morse code, such as the name of your best friend, grandmother, or cousin. Remember to leave spaces between each letter, and write the code for a full stop at the end of the message. When you are done, give your paper to your partner to interpret.

Remember that digital signals are binary, which means they have two states: they can be either on or off. The length of time the signal is on indicates its meaning.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| The Morse Code Alphabet | | | | |
| A **.-**  B **-...**  C **-.-.**  D **-..**  E **.**  F **..-.**  G **--.**  H **....** | I **..**  J **.---**  K **-.-**  L **.-..**  M **--**  N **-.**  O **---**  P **.--.** | Q **--.-**  R **.-.**  S **...**  T **-**  U **..-**  V **...-**  W **.--**  X **-..-** | Y **-.—**  Z **--..**  0 **-----**  1 **.----**  2 **..---**  3 **...—**  4 **....-**  5 **.....** | 6 **-....**  7 **--...**  8 **---..**  9 **----.**  Full stop **.-.-.-**  Comma **--..--**  Query **..--..** |

Someone’s name in Morse code:

Translation into English:

Student Resource 2.4

Interactive Reading:   
Comparing Circuit- and Packet-Switched Networks

Student Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date:\_\_\_\_\_\_\_\_\_\_\_

Directions: This reading explains how circuit-switched and packet-switched networks function. While you are reading, you will be asked to draw some important parts of the networks and to answer some questions about them. When you have completed the reading, it will serve as a reference for other activities in this lesson, such as the quiz at the end of the lesson.

As you work through the reading and exercises, fill in the following table to create a summary of what you learn.

|  | Circuit-Switched Networks | Packet-Switched Networks |
| --- | --- | --- |
| **Signal Type** |  |  |
| **Type of Wiring and Connection** |  |  |
| **Advantages** |  |  |
| **Disadvantages** |  |  |

Part 1: What’s a Circuit?

A *circuit* is a continuous connection between two or more points. Two telephones connected together complete one circuit. When those points are connected, other people cannot use the same line to make another connection. Since telephone connections are an example of an electric circuit and the connections get switched based on who’s calling whom at a given moment, they are called *circuit-switched networks*.

Draw a Circuit

For example, your diagram could include two telephones with a continuous wire connecting the two, with data going in both directions along the wire.

Did You Know?

Early telephone networks, especially in rural areas, allowed each route to use only one circuit. So, if your neighbor was on the line, you couldn’t use it! If you picked up the phone, you could hear your neighbor’s conversation, because your phone connected to their circuit.

These early lines were called *party lines* and were the source of a lot of town gossip. This is still the way conference calling works today: when you want to talk to two friends at once, you can all connect on the same circuit.

How Are Telephone Networks Connected?

The phone in your home is connected to the larger network by copper wires. For local connections, all the communication might happen on copper wire, but for long distances, the information is converted from the analog signal that travels along the copper into a digital one that travels along fiber-optic cables instead. (Fiber-optic cables use light instead of electric pulses to make the digital signal.) At the end of the line, the digital signal is translated back to analog to travel along the copper wire leading to your friend’s house.

When you place a call, the network knows who you’re trying to call by listening to the tone of your signal, and a switchboard translates the signal and connects your call along a direct route to the person you’re trying to reach. When the connection is made, it becomes an electronic circuit, and the line is reserved for your phone call for its duration, as long as you stay on the line.

Draw a Telephone Network

For example, you could draw your house and your friend’s house, each with a telephone, and then show the copper wires and fiber-optic cables that make the connection.

Did You Know?

The early phone networks required a human operator to operate the switchboard. The network didn’t recognize special signals, so the operator would ask who you wanted to connect with and then manually plug in a cord between your incoming route and the outgoing one.

Part 2: How Computers Communicate: Digital Packet Switching

What Is a Digital Packet?

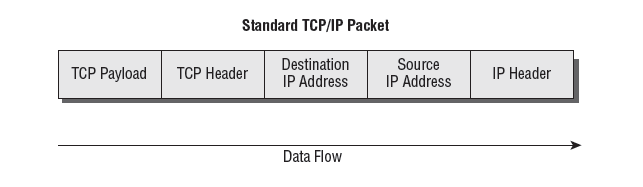
You might define a packet as some kind of package or parcel, something that can be bundled and sent through the U.S. Post Office to a friend. A digital packet is similar.

Computers separate the information they want to send across a network into smaller pieces called *packets*. Before it is sent, each packet gets labeled with an address so that it can travel separately on a different route across the network.

The address also contains information about which order the packets go in so that the computer that receives the packets can reassemble them properly. This process is called *packet switching*.

The information contained in the packet is called its *payload*.

A typical standard TCP/IP packet might be structured like the following diagram (taken from the Wiley CompTIA Network+ Study Guide).



There are two main protocols for digital-packet switching: Internet Protocol (IP) and Multi-Protocol Label Switching (MPLS).

Internet Protocol (IP)

Internet Protocol is a packet-switching technology that can be used for both data and voice transfer. IP packets vary in size and do not travel along a direct connection as in circuit or ATM networks. Instead, packets may be delivered across multiple routes, depending on which route is the fastest at any given moment. Another advantage of IP is that if any part of the connection breaks or becomes slowed down by other network traffic, packets can simply be delivered along other routes.

By sending packets through many computers instead of along a set line, the network can also be expanded by simply adding more computers. If one computer crashes, it doesn’t matter, and communications can continue as usual among the other computers.

Historically, IP networks weren’t very good for voice communications such as telephone calls, because any lag time in the network would cause a loss in voice quality. If one packet arrived later than the one before it, it was too late and had to be dropped.

Recently, standards have changed to give priority to voice packets so that they go through the network more quickly than data packets. The technology that allows transmission of voice calls over packet-switched networks is called voice over IP (VoIP). As networks become faster, telephone calls over the Internet are becoming more and more popular.

Multi-Protocol Label Switching (MPLS)

Multi-Protocol Label Switching (MPLS) is a technology that directs and transports data from one network node to another. By establishing the path for a sequence of data packets, MPLS speeds network traffic flow and makes it easier to manage.

In IP networks, the header of an IP packet has a field that contains the address to which the packet is being routed. This information is processed at every router in a packet’s path on the network.

With MPLS, each packet is given a label. This label is like a shorter version of an IP packet’s header, just like a ZIP code is a short version of a street, city, and state address. Packet-forwarding decisions are made based on the contents of this label, without examining the packet itself. This saves time because the router doesn’t need to look up the address to the next node in order to forward the packet to it.

MPLS is becoming an important technology that offers new capabilities for large IP networks. In addition to increasing network traffic speed, it also supports virtual private networks (VPNs).

Also, because MPLS works with the Internet Protocol (IP), Asynchronous Transport Mode (ATM), and frame relay network protocols, it will become more common as networks begin to carry more and different mixtures of traffic.

Summarize IP and MPLS Similarities and Differences

Use the following chart to summarize the similarities and differences between IP and MPLS.

|  | Internet Protocol  (IP) | Multi-Protocol Label Switching (MPLS) |
| --- | --- | --- |
| **Size of Packets** |  |  |
| **Connection Type** |  |  |
| **What Routes Do**  **Packets Travel?** |  |  |
| **Benefits** |  |  |
| **Disadvantages** |  |  |